

TWO-DIMENSIONAL PHONOTACTICS IN A GENERATIVE GRAMMAR OF GERMAN

by James E. Copeland

Within the frame of reference of generative grammar two quite distinct sorts of apparatus have been proposed by linguists for the phonological component, both of which provide the machinery to generate sentences composed of simultaneous phonological components. I refer on the one hand to the system which employs the Jakobson-Halle type binary distinctive feature system, and on the other to the singulary features called phonons by Lamb and others who are working on the stratificational generative model.¹

In this paper I shall discuss aspects of the latter system in which phonons are the minimal constituents. But I do not restrict the applicability of this system to the stratificational model, since it is quite probable that this type of component could be coupled to a transformational generative grammar with equal suitability.

Traditionally, a pair like German *Pass*, "passport" and *Bass*, "bass" has been considered as evidence for the minimal phonological elements /p/ and /b/, yet /p/ is more similar to /b/ than to /d/ in *das*, and /p/ is more similar to /d/ than to /n/ in *nass*. The necessity for some kind of distinctive feature system to account for such similarity is by now well established. Thus, on examining the German pair *Pass* and *Bass* we discover that the first segmental member of each contains similar elements except in one instance. That is, segments /p/ and /b/ share *stopness* and *labiality* but /b/ contains the glottal element *voicing* while /p/ lacks that element. We can illustrate this as follows: /p/, /b/

St	St
Lb	Lb
	Gl

This constitutes a minimal difference. The terms of all such minimal differences, which are audible to a native speaker, are *phonons*. Every phonological sentence consists of an arrangement

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of phonons of which a language has a fixed number. The requirements for a generative grammar of a spoken language, then, necessarily include a format for generating arrays of simultaneous components which, in turn, generate a speech signal.

Although the frame of reference in this paper is generative, the primary focus is not on the set of rules which generate phonon arrays from strings of higher level elements, but rather on the phonons themselves and on an appropriate framework within which to describe their distributions, that is, on the phonotactics, a phonotactics designed to handle two-dimensional contexts rather than exclusively linear ones.

For the present we shall refer to a simultaneous bundle of phonons as a *character*. Each character is an unordered set of phonons. Two characters are different just in case they do not contain the same phonons, i.e., each must be a unique combination of phonons.

Within this frame of reference, grouping of allophones into phonemes is eliminated, so that the question as to the phonemic status of such pairs in German /ç/ and /x/ becomes irrelevant. Redundancy of the kind which is characterized by such grouping may be eliminated by omitting from the notation any articulatory feature or phonon in an environment in which its occurrence is predictable.

For additional terminology in this format we follow Hockett.² A *subcharacter* is any subset of a character including the null subset and the character itself. A *stepstring* is a string of subcharacters. A *stepmatrix* is a string of characters, each of which is composed of one or more phonons. For example, a stepmatrix for *Pass* takes the form:

$$Pass \quad \begin{vmatrix} St & Sy & Sp \\ Lb & Lo & Ap \\ As \end{vmatrix} \quad (1)$$

where: |St| = stopness, |Lb| = labiality, |As| = aspiration, |Sy| = syllabicity, |Lo| = lowness, |Sp| = spirantness, and |Ap| = apicality.

Phonons for German

The German system contains eleven phonons:

- |Ap| = apicality: the involvement of the apex. (2)
- |Lm| = laminality: the involvement of the front of the tongue.
- |Ds| = dorsality: the involvement of the dorsum.

- |Gl| = glottality: the involvement of the glottis.
- |Lb| = labiality: the involvement of the *lower* lip.
- |St| = stopness: closure at some point in the oral cavity with the velic closed.
- |Ns| = nasality: closure at some point in the oral cavity with the velic open.
- |Sp| = spirantness: close proximity at some point in the oral cavity causing local turbulence in the breath stream.
- |Lo| = lowness: low position of the tongue relative to the palate.
- |As| = aspiration: strong voiceless exhalation.
- |Sy| = syllabicity: high relative sonority.

In addition, there are at least nine phonons dealing with stress and intonation omitted here. The distinctive feature system used here in describing the workings of the phonological system of German is different from previous *phonemic* descriptions in several respects. All junctural phenomena are treated in terms of the articulatory-acoustic features actually *audible* in the speech signal, e.g., glottal stop, aspiration of voiceless stops or additional features such as onset of stress. Higher in the grammar, where the principle of audibility does not apply, a single symbol for plus juncture can be used, but here we are concerned with strictly audible features. Another departure from previous treatments is evident in the choice of features for vowels, which, together with consonants, are described in terms of articulators. /i/ and /e/ have |Lm|, /u/ and /o/ have either |Ds| or |Lb| or both, and /ə/ and /a/ are considered articulator-irrelevant. In addition, members of the pairs /i/ and /e/, /u/ and /o/, and /ə/ and /a/ have to be distinguished by some other articulatory feature, say |Lo| as opposed to its absence. All vowels contain |Sy| and differ from their corresponding semivowels only in this respect. Any additional phonetic features customarily assigned to phones in German are predictable from the presence of these phonons, and any step-matrical system which employs such additional features is isomorphic to this system. The specific set of articulatory features chosen to serve as a point of departure for organizing the machinery of speech production potentially has a direct bearing on the simplicity and economy of a given phonological analysis. It also seems reasonable to assume that in a phonological analysis of English or of some other language the stock of phonons would differ somewhat from the German one, although the universal set from which all articulatory features are drawn is probably fixed.

Evidence for the distinctiveness of *phonons* (not whole segments) is of the sorts shown on the following page.

$$Ap = \emptyset$$

(3)

<i>dessen</i> , "whose"				<i>essen</i> , "to eat"				where: / d / \neq / ? /			
/ d	e	s	n /	versus	/ ?	e	s	n /			
St	Sy	Sp	Sy		St	Sy	Sp	Sy		St	St
Gl	Lm	Ap	Ns		Gl	Lm	Ap	Ns		Gl	Gl
Ap	Lo		Gl			Lo		Gl		Ap	
	Gl		Ap			Gl		Ap			

The first sentence differs from the second sentence by the presence of *one* feature in the first, as opposed to its absence in the second. /desn/ contains [Ap] in the first segment while this feature is absent from /?esn/; otherwise the sentences are identical. Thus, we may define a minimal difference as a distance of 1 between two otherwise identical stepmatrices, and the evidence which establishes the status of a feature as a phonon takes roughly the form of such a minimal pair. Notice that the pair *Pass* = *das* is, under this definition, not a minimal pair since here the distance is

$$3. \begin{array}{|c|c|c|} \hline p & a & s \\ \hline St & Sy & Sp \\ \hline Lb & Lo & Ap \\ \hline \end{array} \quad \begin{array}{|c|c|c|} \hline d & a & s \\ \hline St & Sy & Sp \\ \hline Ap & Lo & Ap \\ \hline Gl & & \\ \hline \end{array}$$

Tactics

There are forty-one characters which are composed of phonons in the combinations as listed in (4):

/h	p'	t'	k'	p	t	k	?	b	d	g	f	s	š	ç	x	v	z	(4)
As	St	St	St	St	St	St	St	St	St	St	Sp	Sp	Sp	Sp	Sp	Sp	Sp	
	Lb	Ap	Ds	Lb	Ap	Ds		Lb	Ap	Ds	Lb	Ap	Lm		Ds	Lb	Ap	
	As	As	As					Gl	Gl	Gl						Gl	Gl	
ž	r	:	w	l	j	Δ	m	n	ŋ	ə	u	l	y	i	Δ	a		
Sp	Sp	Gl	Lb	Ap	Lm	Ds	Ns	Ns	Ns	Sy	Sy	Sy	Sy	Sy	Sy	Sy	Sy	
Lm	Ds						Lb	Ap	Ds		Lb	Ap	Lm	Lm	Ds	Lo		
Gl	Gl														Lb			
o	φ	e	m	n	ŋ	/												
Sy	Sy	Sy	Sy	Sy	Sy	Sy												
Lb	Lm	Lm	Ns	Ns	Ns													
Lo	Lb	Lo	Lb	Ap	Ds													
Lo																		

The order in which the phonons are listed in vertical environments is arbitrary. The notation omits phonons in environments in which their occurrence is predictable, and those which have been omitted

in this display are shown to be determined in vertical environments by the ordered rules C1-C7.

C1.	$\begin{vmatrix} \text{St} \\ \# \end{vmatrix} \rightarrow \begin{vmatrix} \text{St} \\ \text{Gl} \end{vmatrix}$	C5.	$\begin{vmatrix} \text{Ds} \\ \tilde{\text{Lb}} \\ \tilde{\text{Z}} \end{vmatrix} \rightarrow \begin{vmatrix} \text{Ds} \\ \text{Lo} \end{vmatrix}$	(5)
C2.	$\begin{vmatrix} \text{Sy} \\ \tilde{\text{Ns}} \end{vmatrix} \rightarrow \begin{vmatrix} \text{Sy} \\ \text{Gl} \end{vmatrix}$	C6.	$\begin{vmatrix} \text{Sp} \\ \text{Lm} \end{vmatrix} \rightarrow \begin{vmatrix} \text{Sp} \\ \text{Lm} \\ \text{Lb} \end{vmatrix}$	
C3.	$\begin{vmatrix} \text{X} \\ \tilde{\text{Gl}} \\ \tilde{\text{Y}} \end{vmatrix} \rightarrow \begin{vmatrix} \text{X} \\ \text{Gl} \end{vmatrix}$	C7.	$\begin{vmatrix} \text{Sp} \\ \# \end{vmatrix} \rightarrow \begin{vmatrix} \text{Sp} \\ \text{Lm} \end{vmatrix}$	
C4.	$\begin{vmatrix} \text{Lb} \\ \tilde{\text{Z}} \\ \tilde{\text{E}} \end{vmatrix} \rightarrow \begin{vmatrix} \text{Lb} \\ \text{Ds} \end{vmatrix}$			

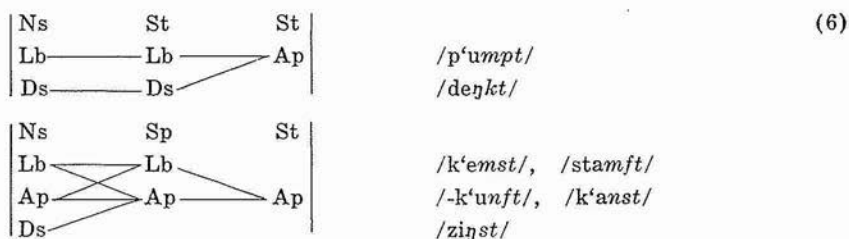
Cover Symbols:	$ \text{X} = \text{Lb} \vee \text{Ap} \vee \text{Lm} \vee \text{Ds} $
	$ \text{Y} = \text{St} \vee \text{Sp} $
	$ \text{Z} = \text{St} \vee \text{Sp} \vee \text{Ns} $
	$ \text{E} = \text{Ap} \vee \text{Lm} $
	$ \tilde{\text{X}} = \text{the absence of } \text{X} $
	$ \# = \text{'no additional phonons'}$

This set of rules is part of the tactic subcomponent of the phonological stratum. As Lamb has demonstrated, it is the task of the tactics *both* to supply the environmental requirements for realizational rules *and* to write-in any determined elements which are relevant only to the next lower stratum in the grammar. The output of the C-rules shown here, along with all characters in (4) which are not changed by the rules, is a set of characters which marks all occurrences of phonons, whether or not they are determined in strictly *vertical* environments. The conditioning environments for these rules are all stated in terms of *cooccurrent* features. It will be noted that the characters in (3) are fuller than those in (4), since for those in (3), the C-rules have been applied. It is always necessary to employ full characters in the minimal pair procedure.

The privileges of occurrence of phonons in two dimensional arrays are describable both in terms of vertical environments (as illustrated in (4) and (5)) and of horizontal environments in stepstrings. For example, we say that $|\text{As}|$ and $|\text{Gl}|$ may not cooccur in the same subcharacter, but that in a sequence the subcharacter $|\text{Sy}|$ may not immediately precede $|\text{Sy}|$, i.e., the stepstring $|\text{Sy Sy}|$ is not allowed by the tactics. Having stated the limitations of co-occurrence of phonons in vertical environments, I shall now suggest a frame of reference for stating the restrictions on the priv-

ileges of occurrence of phonons in two-dimensional contexts, taking into account both vertical and horizontal environments.

If we define phonological word segments for German in the traditional way using junctural phenomena and syllable peaks as a point of departure, we have syllable onsets, peaks, interludes, and codas, which are structurally well defined, as a base from which to describe the possible arrangements of phonons. The diagram below characterizes a subset of codas of length three for German.



Any coda of length three is a member of this subset if the stepstring constituted by the top row of phonons in the diagram is present in the coda. This stepstring makes up what may be called the determining context. In displaying the possible combinations of subcharacters in stepstrings we denote by a diagram of this type that a stepstring [Ns St St] must, in a specified context (in this case in a coda of length three), be coterminous with one or another of the stepstrings [Lb Lb Ap] or [Ds Ds Ap]. The second diagram in (6) characterizes a somewhat larger subset of codas of length three. There are five members in this subclass, as shown.

Following the previously stated principle that phonons need not be included in environments in which they are determined, we may delete from the notation one phonon, in each case where the phonotactics allows only a specified set of phonons to occur. For example, since for the third member of both codas characterized by the first diagram in (6) the only phonon permitted to cooccur with [St] is [Ap], the presence of [Ap] is determined in this environment and need not be marked in either of the codas characterized by this diagram. Further, since for the remaining two members of this pair of codas, (i. e., the occupants of positions 2 and 3), the choice is between [Lb] and [Ds], we may delete one or the other of [Lb] or [Ds] since its occurrence is always predictable from the presence or the absence of the other. If [Ds] is deleted in both these characters a tactic rule will supply it, in each case, where [Lb] is not present in the determining context. In this case the rules take roughly the form:

Conventions: $\begin{vmatrix} X \\ nm \end{vmatrix} = |X|$ in position n of a stepstring of length m (7) (coda).

$\begin{vmatrix} \tilde{X} \end{vmatrix} =$ the absence of $|X|$.

$$R1. \begin{vmatrix} Ns \\ Ds \end{vmatrix} \rightarrow \begin{vmatrix} Ns \\ Ds \end{vmatrix} \text{ in env. } \begin{vmatrix} Sy & \text{---} & St_{23} & St_{33} \\ & \tilde{Lb} & & \end{vmatrix}$$

$$R2. \begin{vmatrix} St \\ Ds \end{vmatrix} \rightarrow \begin{vmatrix} St \\ Ds \end{vmatrix} \text{ in env. } \begin{vmatrix} Sy & Ns_{13} & \text{---} & St_{33} \\ & & \tilde{Lb} & \end{vmatrix}$$

$$R3. \begin{vmatrix} St \\ Ap \end{vmatrix} \rightarrow \begin{vmatrix} St \\ Ap \end{vmatrix} \text{ in env. } \begin{vmatrix} Sy & Ns_{13} & St_{23} & \text{---} \end{vmatrix}$$

Thus, we write the coda of /p'umpt/ as $\begin{vmatrix} Ns & St & St \\ Lb & Lb \end{vmatrix}$, instead of the

fuller form containing the stepstring $|\phi \phi Ap|$, and the coda of /deŋkt/ as $|Ns St St|$, in place of the fuller form containing the stepstring $|Ds Ds Ap|$; and an appropriate set of rules of the type shown in (7) located in the tactics of this stratum will automatically write-in the determined features when a sentence is being generated. Such a sequence of rules for each relevant phonon structure or stepmatrix in the language provides for all tactically determined features and appropriately relegates to the tactics the task of handling the irrelevant features.

Examples:

$$\begin{vmatrix} Ns & St & St \\ Lb & Lb \end{vmatrix} \rightarrow \begin{vmatrix} Ns & St & St \\ Lb & Lb & Ap \end{vmatrix} \quad /p'umpt/$$

$$\begin{vmatrix} Ns & St & St \\ Ds & Ds & Ap \end{vmatrix} \rightarrow \begin{vmatrix} Ns & St & St \\ Ds & Ds & Ap \end{vmatrix} \quad /deŋkt/$$

NOTES

1. Sidney M. Lamb, "Prolegomena to a Theory of Phonology," *Language*, XLII (April-June 1966), 536-573.

2. Charles F. Hockett, "Four Lectures on Theoretical Linguistics" (unpublished), 1964; *Language, Mathematics and Linguistics* ("Janua Linguarum," 60 [The Hague, 1966]), pp. 81-133.